REFRIGERATION SYSTEM AND COMPRESSOR THEREOF

TECHNICAL FIELD

The present invention relates to a refrigeration system such as a refrigerator, air conditioner, etc., and a compressor thereof.

BACKGROUND ART

A refrigeration cycle as a thermodynamic cycle is called as a refrigeration cycle when heat is extracted from a cold reservoir by applying work, and is called as a heat pump cycle when heat is supplied to a hot reservoir, which are generally all called as the refrigeration cycle.

A system having the refrigeration cycle is called as a refrigeration system, which is used in a refrigerator, an air conditioner, a heat pump, and etc.

Figure 1 is a conceptual view showing a construction of a general refrigeration system and Figure 2 is a P-h diagram of the refrigeration system of Figure 1.

As shown in Figures 1 and 2, the refrigeration system comprises: a condenser 1 for radiating heat from refrigerant outwardly under a constant pressure; an expansion device 20 such as a capillary tube or an expansion valve for adiabatic-expanding refrigerant introduced from the condenser 10; an

evaporator 30 for absorbing heat from refrigerant which passed through the expansion device 20 from outside under a predetermined constant pressure; and a compressor 40 for compressing the refrigerant which passed through the evaporator 30.

The refrigeration system receives work W_c from outside to compress refrigerant in the compressor 40 (1->4), and the refrigerant compressed in the compressor 40 passes through the condenser 10 to radiate heat of the refrigerant outwardly (2->3). The refrigerant which passed through the condenser 10 passes through the expansion device 20 to be adiabatically expanded (3->4), and the refrigerant which passed through the expansion device 20 passed through the evaporator 30, absorbs external heat (4->1), and flows to the compressor 40, thereby constituting a refrigeration cycle.

In the meantime, a performance of the refrigeration system is represented as a coefficient of performance COP, and the COP is defined as the following equation 1.

<u>Equation 1</u>

$$COP_R = \frac{Q_L}{W} \quad \text{or} \quad COP_H = \frac{Q_H}{W}$$

Herein, the COP_R denotes a coefficient of performance of a refrigeration system, the COP_H denotes a coefficient of performance of a heat pump, the Q_L denotes heat quantity absorbed in the cold reservoir such as an evaporator, the Q_H denotes heat quantity emitted from the hot reservoir such as a

condenser, and W denotes work applied to the refrigeration system from outside by using a compressor.

Also, the coefficient of performance of the refrigeration system is different according to a construction of the refrigeration system, a performance of the compressor, and a kind of the refrigerant. Herein, in order to construct more efficient refrigeration system, proper refrigerant has to be selected and an efficient refrigeration system has to be constructed.

Besides, since Freon gas widely used in the refrigeration system as a refrigerant is know to destroy ozone layer in the earth, substitution refrigerant has to be developed.

DISCLOSURE OF THE INVENTION

Therefore, it is an object of the present invention to provide a refrigeration system having a structure that increases a coefficient of performance thereof and a compressor of the refrigeration system.

To achieve these objects, there is provided a refrigeration system comprising: a heat absorption unit for absorbing heat from a peripheral portion to fluid under a predetermined constant pressure; a first compression unit for sucking the fluid discharged from the heat absorption unit and compressing; an intermediate cooling unit for cooling the fluid compressed in the first compression unit; a second compression unit for re-compressing the fluid discharged from the intermediate cooling unit; a heat radiating unit for radiating

heat from the fluid compressed in the second compression unit and discharged to a peripheral portion under a predetermined constant pressure; an expansion unit for lowering pressure of the fluid which passed through the heat radiating unit by an adiabatic expansion and driving the first compression unit and the second compression unit by work generated from the expansion; and a cooling flow path for passing the fluid discharged from the expansion unit through the intermediate cooling unit.

To achieve these objects, there is also provided a cooling system comprising: a heat absorption unit for absorbing heat from a peripheral portion to fluid under a predetermined constant pressure; a compression unit for sucking the fluid discharged from the heat absorption unit and compressing; a heat radiating unit for radiating heat from the fluid compressed in the compression unit and discharged to a peripheral portion under a predetermined constant pressure; and an expansion unit for lowering pressure of the fluid which passed through the heat radiating unit by an adiabatic expansion and driving the first compression unit and the second compression unit by work generated from the expansion.

To achieve these objects, there is still also provided a compressor of a refrigeration system comprising: a driving unit; a compression unit for compressing fluid by a driving of the driving unit and discharging to the heat radiating unit; and an expansion unit for lowering pressure of the fluid which passed through the heat radiating unit by an adiabatic expansion and driving the compression unit by work generated from the expansion.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a conceptual view showing a construction of a general refrigeration system;

Figure 2 is a P-h diagram of the refrigeration system of Figure 1;

Figure 3 is a conceptual view showing a construction of a refrigeration system according to the present invention;

Figure 4 is a P-h diagram of the refrigeration system of Figure 3;

Figure 5 is a construction view showing a construction of a compression unit of the refrigeration system of Figure 3;

Figure 6 is a sectional view of the compression unit of Figure 5;

Figure 7 is a perspective view showing a part of the compression unit of Figure 5;

Figure 8 is a geometrically conceptual view showing an inner gear and an outer gear of Figure 7; and

Figure 9 is a graph that compares torque change generated at the compression unit of the present invention with those generated at the conventional compression devices.

MODES FOR CARRYING OUT THE PREFERRED EMBODIMENTS

Hereinafter, the refrigeration system and the compressor thereof

according to the present invention will be explained with reference to the attached drawings in detail.

Figure 3 is a conceptual view showing a construction of a refrigeration system according to the present invention, and Figure 4 is a P-h diagram of the refrigeration system of Figure 3.

As shown in Figures 3 and 4, the refrigeration system according to the present invention comprises: a heat absorption unit 300 for absorbing heat from a peripheral portion to fluid under a predetermined constant pressure; a compression unit 400 for sucking the fluid discharged from the heat absorption unit 300 and compressing; a heat radiating unit 100 for radiating heat from the fluid compressed in the compression unit 400 and discharged to a peripheral portion under a predetermined constant pressure; and an expansion unit 200 for lowering pressure of the fluid which passed through the heat radiating unit 100 by an adiabatic expansion and driving the compression unit 400 by work generated from the expansion.

The refrigeration system according to the present invention can be applied to a refrigerator, an air conditioner, heat pump, etc.

The compression unit 400 of the refrigeration system according to the present invention is constructed as a unit with the expansion unit 200 of the refrigeration system.

The heat radiating unit 100 is a high temperature heat exchanger, which is a generally condenser. Also, the heat absorption unit 300 is a low temperature heat exchanger, which is a generally evaporator.

Fluid used in the refrigeration system according to the present invention, that is, refrigerant may include several types of refrigerant. In the present invention, carbon dioxide CO_2 can be also used.

The carbon dioxide can be used for relatively long time, and is neither toxic, nor combustible. Also, the carbon dioxide having a low price and abundant sources is not required to re-collect and is well solved with lubricating oil. Besides, since cooling amount per unit capacity thereof is five times when compared with CFC based R-22, a capacity for generating the same refrigeration capacity becomes small and a compression ratio becomes also small.

However, the carbon dioxide has a ratio of heat capacities k corresponding to 1.4, which is larger than those of the CFC based R-22 and R-134a corresponding to 1.0 ~1.1. The greater the ratio of heat capacities is in an adiabatic compression process of the refrigeration cycle, the more temperature of the refrigerant is increased. At this time, the increased temperature influences to oil, material, a motor winding for driving it, and etc in the compression device for performing the adiabatic compression.

Especially, temperature of the carbon dioxide is increased from 30°C to 200 °C when the carbon dioxide is compressed with a suction pressure of 30kgf/cm^2 and a discharge pressure of 150kgf/cm^2, so that oil having deterioration temperature of 190~230°C is deteriorated.

Accordingly, the refrigeration system according to the present invention has a structure which compresses fluid several times by a plurality of sub

compression units like the compression unit 400 which will be later explained, thereby having high coefficient of performance even if the carbon dioxide is used as refrigerant.

Figure 5 is a construction view showing a construction of a compression unit of the refrigeration system of Figure 3.

As shown in Figure 5, the compression unit 400 is composed of at least one sub compression unit which compresses the fluid several times by being installed sequentially. The number of the sub compression units is one or plural, and in the preferred embodiment of the present invention, two sub compression units composed of the first compression unit 410 and the second compression unit 420 are constructed.

Also, the refrigeration system according to the present invention further comprises a plurality of intermediate cooling units 500, respectively installed between the plurality of sub compression units for cooling fluid compressed in each sub compression unit.

A flow path (not shown) for connecting the expansion unit 200 and the heat absorption unit 300 includes a cooling flow path 510 installed for making the fluid discharged from the expansion unit 200 pass through the intermediate cooling unit 500.

The intermediate cooling unit 500 is constructed by being contacted to a flow path (not shown) which connects the sub compression units and to the cooling flow path 510 for exchanging heat each other, or can be constructed as another heat exchange device (not shown) such as plate-type heat exchanger,

etc.

As shown in Figures 5 and 6, the first compression unit 410 and the second compression unit 420 as sub compression units are sequentially connected to a driving shaft 610 of the driving unit 600. Also, the expansion unit 200 is connected to the driving shaft 610 so that the fluid can be expanded and thereby the driving shaft 610 be rotated to a direction which the fluid is compressed. Especially, since the expansion unit 200 is used with the driving shaft 610, the work generated from the expansion unit 200 can be transmitted to the compression unit 400. The sub compression units of the compression unit 400 can be connected to the driving shaft 610 together or separately.

As the driving unit 600, an electric motor that generates a rotation force by electric energy is used. However, any device that generates a driving force can be used.

Partition wall units 711 and 712 are installed among the first compression unit 410, the second compression unit 420, and the expansion unit 200. Also, external wall units 721 and 722 for respectively forming a compression chamber and an expansion chamber are installed at a front end portion of the first compression unit 410 and a rear end portion of the expansion unit 200.

At the external wall unit 721 installed at the front end portion of the first compression unit 410, a bearing unit 611 into which the driving shaft 610 is rotatably inserted is installed, and a first suction port 411 for sucking the fluid to the compression chamber of the first compression unit 410 and a first

discharge port 412 for discharging the fluid from the first compression unit 410 are formed.

At the partition wall unit 711 installed between the first compression unit 410 and the second compression unit 420, formed is a second suction port 421 for sucking the fluid from the intermediate cooling unit 500 to the compression chamber of the second compression unit 420.

At the partition wall unit 712 installed between the second compression unit 420 and the expansion unit 300, formed are a second discharge port 422 for discharging the fluid from the second compression unit 420 and a third suction port 210 for sucking the fluid from the heat radiating unit 100 to the expansion unit 200.

At the external wall unit 722 installed at the opposite side of the second partition wall unit 712 on the basis of the expansion unit 200, formed is a third discharge port 220 for discharging the fluid from the expansion unit 200.

Herein, it is possible that the first compression unit 410, the suction port and discharge port of the second compression unit 420 are formed in any radial direction of the driving shaft 610. However, it is preferable that they are formed at the same side on the basis of the driving shaft 610, and the suction ports and discharge ports of the first compression unit 410 and the second compression unit 420 are formed to face one another on the basis of the driving shaft 610.

Also, it is preferable that the suction port and discharge port of the expansion unit 200 are respectively formed at the opposite side of the suction

ports and discharge ports of the first compression unit 410 and the second compression unit 420.

The first compression unit 410 and the second compression unit 420 as the sub compression units of the compression unit 400, and the expansion unit 200 respectively form the compression chamber and the expansion chamber by the external wall units 711 and 712 or by the partition wall units 721 and 722.

Figure 7 is a perspective view showing a part of the compression unit of Figure 5, and Figure 8 is a geometrically conceptual view showing an inner gear and an outer gear of Figure 7.

As shown in Figures 7 and 8, the first compression unit 410, the second compression unit 420, and the expansion unit 200 respectively includes an inner gear 810 engaged to the driving shaft 610 to rotate and having a plurality of teeth 811 at an outer circumference surface; and an outer gear 820 having insertion teeth 821, the number of which is more than that of teeth 811 of the inner gear 810 at an inner circumference surface of the inner gear 810 insertable by the plurality of teeth 811 and having a center O_2 which is eccentric with a rotation shaft, i.e. a center O_1 of the inner gear 810.

As shown in Figures 7 and 8, the inner gear 810 rotates by being engaged to the driving shaft 610, and has six teeth 811 at the outer circumference surface. Even if the teeth 811 can have any shape, it is preferable that a cycloid curve is formed.

As shown in Figures 7 and 8, the outer gear 820 includes the insertion

teeth 821 at the inner circumference surface thereof insertable by the plurality of teeth 811 of the inner gear 810, in which the number of the insertion teeth 821 is 7 more than the teeth 811 of the inner gear 810. At this time, the outer gear 820 may be rotatable even if it can be fixed.

Even if the insertion teeth 821 have any shape, a combination of three circular arcs having different radius of curvature is preferred.

Especially, torque change amount generated when the sub compression units are compressed is remarkably smaller than at a compression unit having another structure, which is shown in Figure 9.

In Figure 9, an axis of ordinate denotes a torque ratio obtained by dividing each value by an average value of torque generated at the time of rotation, and an axis of abscissa denotes a rotation angle.

Also, when the outer gear 820 is rotatable with the inner gear 810, maintaining balance of force and torque attenuates vibration and noise. Especially, by contacting the plurality of teeth 811 to the insertion teeth 821, the generated force is not concentrated inwardly but distributed and its structure is simple.

Also, a speed difference when the teeth 811 is meshed with the insertion teeth 821 each other at a meshing point, that is, relative speed is small.

The outer gears 820 and the inner gears 810 of first compression unit 410, the second compression unit 420, or the expansion unit 200 have different thickness according to the required volumes of the compression chamber and

the expansion chamber, and it is preferable that the radii of the outer gears 820 and the inner gears 810 of first compression unit 410, the second compression unit 420, or the expansion unit 200 are equally constructed.

In the meantime, the expansion unit 200 is constructed to suck and discharge in a direction opposite to those of the suction and discharge of the first compression unit 410 and the second compression unit 420, thereby sucking the fluid which passed through the heat radiating unit 100 to the expansion chamber, adiabatically expanding, and discharging to the cooling flow path 510. At this time, work generated in the process of the adiabatic expansion is transmitted to the first compression unit 410 and/or the second compression unit 420 through the driving shaft 610 engaged to the expansion unit 200, thereby reducing driving energy necessary to the driving unit 600 and enhancing entire coefficient of performance COP of the refrigeration system.

The refrigeration system according to the present invention and operations of the compressor will be explained in detail.

As shown in Figures 3 and 4, in the refrigeration system according to the present invention, the compression unit 400 starts to compress the fluid according to operations of the driving unit 600 (1->4). The fluid compressed in the compression unit 400 flows to the heat radiating unit 100 such as a condenser along a flow path (not shown), passes through the heat radiating unit 100, and radiates heat of the fluid outwardly (4->5).

The fluid which passed through the heat radiating unit 100 passes through the expansion unit 200 through the flow path (not shown). At this time,

work generated when the fluid is adiabatically expanded is transmitted to the compression unit 400 by connecting the expansion unit 200 with the driving shaft 610 of the driving unit 600 (5->6).

The fluid that passed through the expansion unit 200 flows to the heat absorption unit 300 through the flow path (not shown), and the fluid absorbs heat from outside by passing through the heat absorption unit 300 (7->1).

The fluid that passed through the heat absorption unit 300 flows back to the compression unit 400, thereby forming a refrigeration cycle.

In the meantime, in case that the compression unit 400 is composed of a plurality of sub compression units, for example, the first compression unit 410 and the second compression unit 420, the fluid which passed through the heat absorption unit 300 is sucked to the first compression unit 410, compressed, and discharged (1->2). The discharged fluid is sucked to the second compression unit 420 again, and compressed. At this time, the fluid which passed through the intermediate cooling unit 500 in which the cooling flow path 510 is installed, is cooled, and sucked to the second compression unit 420 (2->3). Then, the fluid once more compressed in the second compression unit 420 is discharged to the heat radiating unit 100 (3->4).

In the meantime, coefficients of performance of the refrigeration systems according to the present invention and the conventional art are shown in table 1. As shown in table 1, the coefficient of performance of the present invention is much more increased than that of the conventional refrigeration system in which carbon dioxide or R-22 is used as refrigerant.

Table 1

Division	Coefficient of performance (COP)	ε (t_0=7°C)
The present invention	3.97	0.32
Comparative example1 (CO_2)	2.89	0.23
Comparative example2 (R-22)	3.88	0.31

Herein, in the present invention, the carbon dioxide is used as refrigerant and a gear compressor having two sub compression units is used as the compression unit. Also, in the comparative example 1, the carbon dioxide is used as refrigerant and has two compression processes and throttle. In the comparative example 2, the R-22 is used as refrigerant.

The refrigeration system according to the present invention has a simple structure, easy fabricating processes, and an enhanced coefficient of performance even if the carbon dioxide having a high ratio of heat capacities is used as refrigerant.

Also, the compressor of the refrigeration system according to the present invention has a strong endurance for high pressure and has less vibration and noise resulting from that the inner gear is rotated with the outer gear.

Besides, the compressor of the refrigeration system according to the present invention has change width of the torque less than another compressors at the time of the operation, and the generated torque is distributed to the plurality of teeth and the insertion teeth formed at the inner

gear and the outer gear without being concentrated inwardly.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.